REPORT ON
THE ELTRON FAULT LOCATOR

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REPORT ON
THE ELTRON FAULT LOCATOR

A. General

At the request of the Engineering Division, an investigation of a new power line fault locator known by the trade name of Eltron Fault Locator* was undertaken by the Technical Standards Division.

The fault locator consists of a light, portable, self-contained, battery powered, audio frequency detector-amplifier with an indicating output meter and selective band-pass filters for 60 and 300 cycles. The detector-amplifier is shown in Figure 1. A shielded loop on a five-foot staff is used to pick up and trace the test signal to the fault. The loop is shown in Figures 2 and 3. The test signal is obtained by connecting a 15 kva test capacitor in series with the energized power line and the faulted section. The test capacitor with mounting bracket is shown in Figure 4. The capacitor charging current, including the harmonics present, flows into the faulted section, through the fault and into the ground. This test current, under certain conditions, can be traced to the point of the fault, provided the voltage is sufficiently high to break down the fault. A test fuse is connected in series with the capacitor and the line. This is shown in Figure 5.

The manufacturer's trade literature describing the device in more detail is available in the files of the Technical Standards Division. The device is priced at approximately $300.

B. Summary of Findings

1. The Eltron Fault Locator will perform as claimed in the new Eltron Fault Locator Instruction Manual, a copy of which is on file in the Technical Standards Division.

2. The Eltron Fault Locator will locate the type of faults that are of a permanent nature, i.e., a direct phase to ground fault or a fault that will arc when the faulted section of line is energized through the test capacitor.

3. The device will not and is not intended to locate radio interference or "leaky" insulators. It will not locate faults of an intermittent nature, or faults that will not operate a sectionalizing device.

4. Use of the device is not considered hazardous provided accepted hot line practices are followed.

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* Manufactured by Eltron, Inc., Jackson, Michigan, formerly known as Raytron, Inc. The Eltron Fault Locator was originally sold under the name Raytron Electronic Fault Locator.

REPORT ON
THE SITRON FAULT LOCATOR

1. General

At the request of the Engineering Division, an investigation of a new power line fault locator known by the trade name of Sitron Fault Locator* was undertaken by the Technical Standards Division.

The fault locator consists of a light, portable, self-contained, battery powered, audio frequency detector-amplifier with an indicating output meter and selective band-pass filters for 60 and 300 cycles. The detector-amplifier is shown in Figure 1. A pickup loop or a direction coil is used to pick up and trace the test signal to the fault. The loop is shown in Figures 2 and 3. The test signal is obtained by discharging a [illegible] kv test capacitor in series with the energized power line and the faulted section. The test capacitor with [illegible] breaker is shown in Figure 4. The capacitor charging current, including the harmonics thereof, flows into the faulted section, through the fault and into the ground. This test current, under certain conditions, can be traced to the point of the fault, provided the voltage is sufficiently high to break down the fault. A test [illegible] is connected in series with the capacitor and the line. This is shown in Figure 5.

The manufacturer's trade literature describing the device in more detail is available in the files of the Technical Standards Division. The device is priced at approximately $350.

2. Summary of Findings

1. The Sitron Fault Locator will perform as outlined in the Sitron Fault Locator Instruction Manual, a copy of which is on file in the Technical Standards Division.

2. The Sitron Fault Locator will locate and trace [illegible] faults which are of a permanent nature, i.e., a direct phase to ground fault, or a fault that will arc when the faulted section of line is energized through the test capacitor.

3. The device will not and is not intended to locate high resistance or "leaky" insulators. It will not locate faults of an intermittent nature, or faults that will not operate a sectionalizing device.

4. Use of the device is not considered hazardous provided the normal hot line practices are followed.

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* Manufactured by Sitron, Inc., Jackson, Michigan, formerly known as [illegible]. The Sitron Fault Locator was originally sold under the name [illegible] Electronic Fault Locator.

5. The device appears to be soundly constructed in accordance with good engineering practice.

6. When used by a competent operator in accordance with the new instruction manual, the device should determine the location of the fault to within one or two spans, depending upon the location and number of ground connections in the vicinity of the fault.

C. Steps in Investigation

This investigation proceeded in several steps:

1. The manufacturer's trade literature was circulated among engineers throughout REA. Comments were obtained from the several engineering and management regions, from the Performance Analysis Section, from the Labor Relations and Safety Specialist and from others.

2. Comments were solicited from a group of REA Co-op line foremen who had witnessed a demonstration of the device at Hart, Michigan.

3. Comments were solicited from the telephone company at Hart, Michigan as to whether use of the device would cause telephone interference.

4. A letter of inquiry was sent to approximately 30 REA Co-op managers who had purchased these devices.

5. Field tests of the device were conducted on the lines of Prince William Electric Cooperative at Manassas, Virginia, and on the lines of the Southeastern Indiana REMC at Osgood, Indiana. Details of the Indiana tests are described in the appendix.

D. Summary of Comments of REA Engineers

Comments were solicited from REA engineers during the early stages of the investigation, the latter part of 1946. At that time no REA field experience with the device had been gained and most of the following comments were based on a study of the trade literature describing the device:

1. There was some doubt as to safety considerations in connection with energizing a faulted line through a 15 kva capacitor.

2. It was felt that field experience with the device should be obtained before firm conclusions be drawn.

3. There was some question as to the types of faults the device would locate.

6. The device appears to be soundly constructed in accordance with good engineering practice.

7. When used by a competent operator in accordance with the instruction manual, the device should determine the location of the fault to within one or two spans, depending upon the location and number of ground connections in the vicinity of the fault.

C. Steps in Investigation

This investigation proceeded in several steps:

1. The manufacturer's trade literature was circulated among engineers throughout TVA. Comments were obtained from TVA general engineering and management services, from the Maintenance Training Section, from the Labor Relations and Safety Specialist and from others.

2. Comments were solicited from a group of TVA hot-line men who had witnessed a demonstration of the device at Flint, Michigan.

3. Comments were solicited from the telephone company at Flint, Michigan as to whether use of the device would cause telephone interference.

4. A letter of inquiry was sent to approximately 20 REA co-op managers who had purchased these devices.

5. Field tests of the device were conducted on the lines of Prince William Electric Cooperative at Manassas, Virginia, and on the lines of the Southeastern Indiana REMC at Osgood, Indiana. Details of the various tests are described in the appendix.

D. Summary of Comments of TVA Engineers

Comments were solicited from TVA engineers during the early stages of the investigation, the latter part of 1947. At that time no TVA field experience with the device had been gained and most of the following comments were based on a study of the trade literature describing the device.

1. There was some doubt as to safety considerations in connection with energizing a faulted line through a 15 kva capacitor.

2. It was felt that field experience with the device should be obtained before firm conclusions be drawn.

3. There was some question as to the types of faults the device would locate.

4. A number of engineers wanted to see the device demonstrated.

5. The question of telephone interference arose and inductive interference tests were suggested.

6. It was felt that the device had possibilities and that it should be investigated further.

E. Summary of Comments from REA Co-op Foremen

A special meeting of the REA co-op line foremen of the State of Michigan was held at Hart, Michigan, on December 6, 1946, at which time the Eltron Fault Locator was demonstrated by Eltron representatives. It was the concensus of those present that the demonstration was successful and that a large step forward had been made in locating power line faults.

F. Summary of Comments of Telephone Company

The Michigan Associated Telephone Company at Hart, Michigan, was asked to make noise measurements during the Eltron Fault Locator demonstration at Hart.

Measurements taken at that time showed no increase in noise level.

Comments from American Telephone and Telegraph Company were not solicited.

G. Summary of Comments from REA Co-op Managers

An inquiry regarding the operation and use of the Eltron Fault Locator was sent to a number of REA co-op managers who had purchased these fault locators.

1. Most of the managers replied that they had only recently received their fault locator and that they were in no position to make qualified comments.

2. Those who had learned to use the fault locator felt that it would aid considerably in locating hard-to-find faults.

3. It was evident from the letters of those who were dissatisfied with the fault locator that they did not understand the capabilities or limitations of the instrument and that a more complete instruction manual was needed.

4. All those commenting on the safety aspects of using the fault locator felt that use of the device involved no undue hazards, provided accepted hot line practices were followed.

H. Field Tests

A field demonstration of the fault locator was staged by Eltron, Inc., at Manassas, Virginia, with the cooperation and assistance of Prince William Electric Cooperative. Approximately ten REA engineers were in attendance. The demonstration consisted of staging a concealed phase-to-ground fault and then attempting to locate the fault by using the fault locator.

After a brief explanation of the theory and operation of the device, the engineers present formed into four groups with one fault locator in each group. After installing the test capacitor the faulted section of line was patrolled using the fault locators. Some confusion developed because of the nature of the multi-grounded distribution system. The fault was localized and was finally located visually.

The demonstration definitely indicated a need for working out better operating techniques for using the fault locator on multi-grounded rural distribution systems.

With the cooperation of Mr. Frank E. Ratts, Manager of Southeastern Indiana REMC at Osgood, Indiana, a detailed field testing program was undertaken at Osgood on September 24 to 27, 1947. To carry out these tests a distribution line that had not been placed in regular service was selected. It proved to be a flexible facility for simulating various operating and fault conditions.

Techniques developed during these tests were incorporated in a new instruction manual issued by the manufacturer to all users of the equipment.

I. Conclusions

When used by a competent operator in accordance with the instructions outlined in the new instruction manual, the Eltron Fault Locator should prove to be an asset in locating the types of faults for which it was intended.

Used with lack of understanding, or mis-used, the device may prove to be a handicap.

Figure 1. Detector-Amplifier.

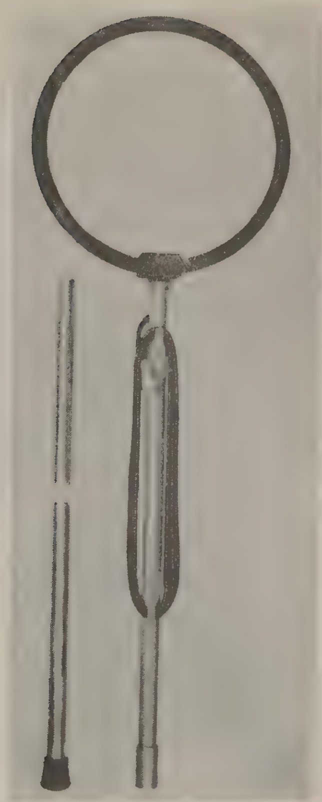


Figure 2. Loop and Extension.

Figure 3. Loop Mounted on Maintenance Truck.

Figure 4. Test Capacitor with Mounting Bracket.

Figure 5. Test Capacitor mounted on pole. The Test Fuse Holder Assembly is seen at the left.

APPENDIX

REPORT ON FIELD TESTS OF ELTRON FAULT LOCATOR

A. General

During 1947 a number of REA-financed systems purchased a device known as the Eltron Fault Locator to be used in locating permanent power system faults. Neither the manufacturer nor the purchasers of this device were familiar with the operating techniques required for locating faults on multi-grounded distribution systems. All of the operating instructions then available were concerned with delta or uni-grounded distribution systems.

B. Purpose of Field Tests

Arrangements were made with the Southeastern Indiana REMC, the manufacturer, the distributor of the equipment and REA engineers to conduct a field testing program from September 24-27, 1947. The following persons participated in these tests:

Messrs. Frank E. Ratts, Mgr. Southeastern Indiana REMC, Osgood, Indiana.

John R. Gelzer, Eltron Inc., Jackson, Michigan.

J. H. Willox, Joslyn Mfg. and Supply Co., Chicago, Illinois.

A. B. Campbell, Joslyn Mfg. and Supply Co., Indianapolis, Indiana.

G. R. Messmer, REA, Washington, D. C.

The purpose of these tests was to:

1. Develop operating techniques for using the device on multi-grounded distribution lines, and to determine the speed and accuracy of the device in locating permanent power system faults.

2. Gather material and photographs for an instruction manual pertaining specifically to multi-grounded rural distribution lines.

3. Obtain data relating to operating problems such as resonance effects, abnormal voltage conditions, and effectiveness of the device on high resistance faults.

4. Determine the aspects of safety to personnel and equipment.

C. Facilities Employed for Field Tests

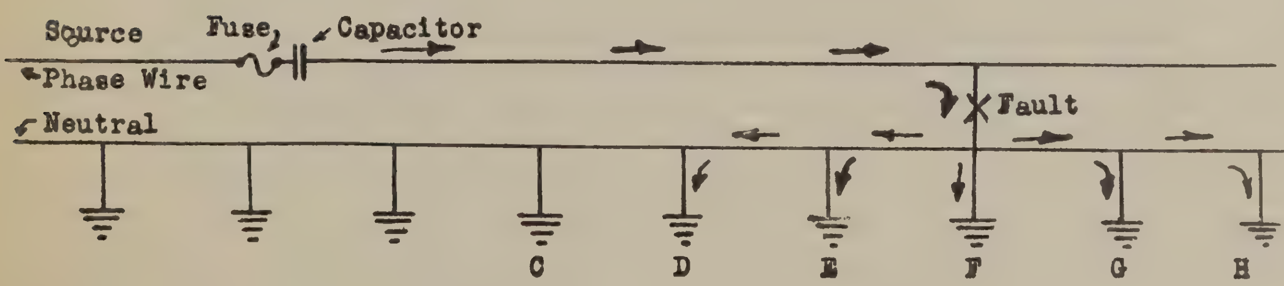
1. Fault Locating Equipment - In addition to the portable indicator unit and loop antenna, a 15 KVA, 7200 volt distribution shunt capacitor with lifting eye and mounting brackets, and a Kearney fuse stick equipped with a 3 ampere type QA fuse were used.

2. To measure line current beyond the capacitor, a conventional clamp-on ammeter was used. In measuring the distribution line voltage beyond the capacitor, a voltmeter was connected to the low side of a distribution transformer. Two-way radio equipment was available to corrdinate operations at the capacitor location with mobile units working in the faulted section of line.

3. Description of distribution line - An eleven mile section of single phase line having several tap and branch lines was available. This line was newly constructed and had not been previously energized. Pole grounds were located on the average at every other pole. Under some test conditions, no distribution transformers were connected to the line while for other tests, a convenient number of distribution transformers with secondaries open-circuited could be connected to the distribution line. An energized three-phase line with single and V-phase branch lines was used for tests on multi-phase lines.

D. Description and Results of Field Tests

1. Several days before the tests commenced, the lineman placed two permanent faults on the single-phase section of line. When the capacitor and fuse stick were installed and energized, a comparatively high reading of the meter on the indicator unit was noted when the loop antenna was oriented with respect to the power line. In patrolling the line, the indication remained substatially constant until approaching a fault. When within several spans of the fault, the meter reading dropped considerably and in some cases increased when the fault was passed. This can be explained by noting the currents in the sketch below:



Assuming a fault at F, the current in the phase wire will flow to the neutral-ground circuit and divide in the various-pole or system grounds in inverse proportion to the ground resistance. Current flowing in the neutral wire between D and F, for example, will tend to cancel the current in the phase wire that produces an indication in the meter. If the neutral-ground circuit from F to H has low resistance, considerable current may flow in the neutral conductor between F and H. For this reason, the indication on the device may be higher at H beyond the fault than it might be at D or E. This situation makes it very difficult to determine the exact location of faults on multi-grounded distribution lines. However, the location of the fault within several span lengths may be determined quite speedily, limited only by the time involved in traversing the section of line in question. Both faults were located visually after following the procedure outlined above.

2. To simulate a high resistance fault, the ladder of a defective valve-type arrester was shorted and the valve element connected phase to neutral. A satisfactory indication was noted on the meter of the indicator unit. This type of fault could be located with the same degree of accuracy as noted in 1 above. The voltage measured on a 120 volt transformer secondary two spans from the capacitor was 65 volts. After the arrester failed more completely due to heating, this voltage dropped to 15. The voltage measured at a transformer 2½ miles from the capacitor indicated 12.5 volts across the 120 volt secondary terminals. When the faulted arrester was removed from the line, the secondary transformer voltage rose to 240 volts for a period of 3 to 4 seconds before the 3 ampere Type QA Kearney fuse operated. Six, 3 KVA transformers were connected to the distribution line during this test. An examination of the fuse time-current curve indicated approximately 5 amperes line current or about 200 percent full load current through the primary winding of each distribution transformer. The capacitor was refused and a current reading 2.5 miles beyond the capacitor indicated that 2.0 amperes line current was flowing with 3 distribution transformers beyond the point the reading was taken.

3. Several more tests were made to determine what overvoltage conditions might exist due to series resonance effects of the test capacitor and distribution transformers. As would be expected, no voltage was measured across transformer secondary terminals at any location on the solidly faulted section of line. However, with 6 transformers connected, the voltage on each transformer rose to 240 volts when the fault was removed for a period of 3 seconds before the fuse operated.

4. Tests on Multi-Phase Lines - While testing was in progress on the single-phase line, an opportunity presented itself to locate an actual fault on a three-phase section of line. The capacitor was installed at a convenient sectionalizing point and the meter reading on the indicator unit was normal. The indication was fairly constant for several miles along the line. When the faulted phase became a single-phase line, all meter indications disappeared, indicating that the fault had passed. When returning to the multi-phase line, a normal reading was again noted. It was finally determined that the meter indication was caused by the normal line currents in one or both of the unfaulted phases. However, the fault location was bracketed by this procedure and the fault (phase wire and neutral tangle) was located by patrol through a section not accessible by truck.

E. Conclusions

1. The Eltron Fault Locator is a useful aid in locating faults on single-phase multi-grounded distribution systems that operate normal sectionalizing devices. The accuracy of location depends somewhat on the grounding scheme in the vicinity of the fault but the location can be determined within several spans about as quickly as the service vehicle can patrol the line.

2. The test capacitor and fuse can be installed in 10 or 15 minutes with the mounting hardware provided. There appears to be no undue hazards to linemen if normal safety practices are observed.

3. The use of the device on multi-phase lines is rather limited for the following reasons:

   a. The capacitor should not be installed if the possibility of a line-to-line fault exists. In this case, the capacitor would be subjected to 1.73 times phase to neutral voltage thus exceeding the 10 percent maximum permissible overvoltage rating of the capacitor.

   b. Line currents in the unfaulted phase or phases will, in most instances, exceed the two ampere tracing current available in the faulted phase. In most cases, it is doubtful that the unfaulted phases can be de-energized while locating a fault on the other phase.

4. The possibility of system undervoltage of overvoltage conditions due to resonance effects and high resistance faults is present. However, if the instructions provided with the device are followed, damage to line equipment or consumer equipment should not result.